
Description

Overview

This document describes the various line cards that are used with the Meridian 1 switch. It shows how the line cards fit into the Meridian 1 architecture, how they are used at the customer site, and how they are installed and programmed. It then provides detailed technical specifications on each of the cards.

These are the eight line cards described in this document:

- NT1R20 Off-Premise Station Analog Line Card
- NT5D11 Line-side T1 Interface Card
- NT8D02 Digital Line Card
- NT8D09 Analog Message Waiting Line Card
- QPC192 Off-Premise Extension Line Card
- QPC452 Basic 500/2500 Line Card
- QPC578 Integrated Services Digital Line Card
- QPC789 16-Port Message Waiting Line Card

Meridian 1 architecture

A Meridian 1 switch is a digital telephone system that provides both voice and data transmission. The internal hardware is divided into the following functional areas (see [Figure 1](#)).

Common equipment

Common equipment circuit cards provide processor control, software execution, and memory functions to the system. Meridian 1 processor functions are executed by the system software in the CPU module (sometimes called a Core module). This module is normally located at the bottom of the Meridian 1 column. The CPU manages the telephone switching functions by responding to interrupt requests from the network and peripheral equipment. It also performs the following housekeeping functions:

- controls call origination, call termination, and feature operation for switched voice and data calls
- executes system administration and configuration functions
- coordinates system diagnostic activities
- controls system utility functions such as software loading, initialization, data dumping, traffic logging, and system auditing

Network equipment

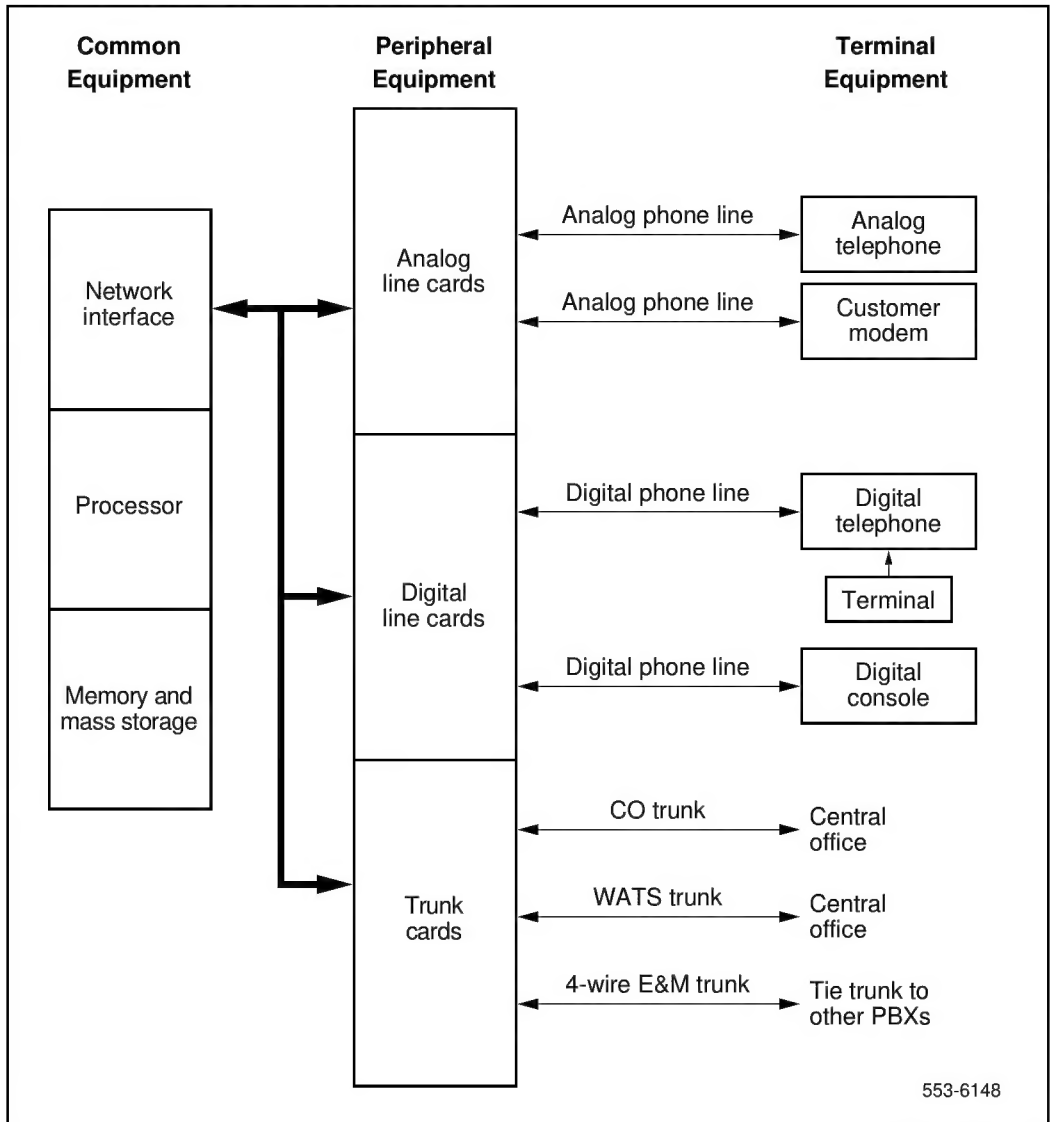
Network interface circuit cards perform data and control switching functions between the processor and peripheral equipment cards.

Note: As shown in [Figure 1](#), the network interface function is generally considered a subset of the common equipment functions.

Some of the functions that network equipment performs include the following:

- hardware initialization and self-test upon power-up
- establishes call connections between stations connected to remote IPE line cards and stations local to the Meridian 1
- establishes call connections to trunks for long distance trunk calls over public or private networks
- provides local and remote loopback testing and fault isolation functions

Figure 1
Line cards in the Meridian 1 architecture



Peripheral equipment

Peripheral equipment circuit cards provide the interface between the network and connected devices, including terminal equipment and trunks. Functions performed by peripheral equipment include the following:

- performs initialization and self-test upon power-up
- manages timeslots for line and trunk cards to establish call connections
- provides Card-LAN management information by reporting card and unit or port status (IPE cards only)
- controls local station dialing and ringing functions
- provides local and remote loopback testing and fault isolation functions
- Provides T1 diagnostic information and fault isolation functions (NT5D11 only)

Line cards are peripheral equipment circuit cards used to connect the Meridian 1 switch to terminal equipment such as telephones and modems over 2-wire (tip and ring) line facilities. The line card (and the terminal equipment that it connects to) can be either analog or digital in nature. Similar line facilities are used for both.

Line-side T1 line cards are used to connect the Meridian 1 switch to T1 compatible terminal equipment within the installation. Line-side T1 equipment can include voice mail systems, voice response units (VRUs), foreign exchange stations (FXS), and key systems such as the Northern Telecom Norstar.

Trunk cards are peripheral equipment circuit cards used to connect the Meridian 1 switch to telephone trunk facilities. Trunk lines are always analog facilities.

Terminal equipment

Terminal equipment includes telephones and attendant consoles. It may also include equipment such as data terminals, printers, and modems.

Complete details on the architecture of the Meridian 1 switch are given in *Meridian 1 system overview* (553-3001-100).

Selecting a line card

Each of the line cards was designed to fit a specific system need. [Table 1](#) will help you select the line card that will best meet your needs.

Table 1
Line card characteristics

Part Number	Description	Lines	Line Type	Message Waiting	Super-vised Analog Lines	Archi- tecture
NT1R20	Off-Premise Station Analog Line Card	8	Analog	Interrupted dial tone	Yes	IPE
NT5D11	Line-side T1 Interface Card	24	T1	None	Yes	IPE
NT8D02	Digital Line Card	16	Digital	Message waiting signal forwarded to digital phone for display	No	IPE
NT8D09	Analog Message Waiting Line Card	16	Analog	Lamp	No	IPE
QPC192	Off-Premise Extension Line Card	4	Analog	None	No	PE
QPC452	Basic 500/2500 Line Card	8	Analog	None	No	PE
QPC578	Integrated Services Digital Line Card	8	Digital	Message waiting signal forwarded to digital phone for display	No	PE
QPC789	16-Port Message Waiting Line Card	16	Analog	Lamp	No	PE

Intelligent peripheral equipment line cards

The following line cards are designed using the Intelligent Peripheral Equipment (IPE) architecture and are recommended for use in all new system designs.

NT1R20 Off-Premise Station Analog Line Card

The NT1R20 Off-Premise Station (OPS) Analog Line Card is an intelligent eight-channel analog line card designed to be used with 2-wire analog terminal equipment such as 500/2500 type phones and analog modems. Each line has integral hazardous and surge voltage protection to protect the Meridian 1 system from damage due to lightning strikes and accidental power line connections. This card is normally used whenever the phone lines have to leave the building in which the Meridian 1 switch is installed. The OPS line card supports message waiting notification by interrupting the dial tone when the receiver is first picked up. It also provides battery reversal answer and disconnect analog line supervision and hook flash disconnect analog line supervision features.

NT5D11 Line-side T1 Interface Card

The NT5D11 Line-side T1 Interface Card is an intelligent 24-channel digital line card that is used to connect the Meridian 1 switch to T1 compatible terminal equipment on the line-side. T1 compatible terminal equipment includes voice mail systems, channel banks containing FXS cards, and key systems such as the Northern Telecom Norstar. The line-side T1 card differs from trunk T1 cards in that it supports terminal equipment features such as hook-flash, transfer, hold, and conference. It emulates an analog line card to the Meridian 1 software.

NT8D02 Digital Line Card

The NT8D02 Digital Line Card is an intelligent 16-channel digital line card that provides voice and data communication links between a Meridian 1 switch and modular digital telephones. Each of the 16 channels support voice-only or simultaneous voice and data service over a single twisted pair of standard telephone wire.

NT8D09 Analog Message Waiting Line Card

The NT8D09 Analog Message Waiting Line Card is an intelligent 16-channel analog line card designed to be used with 2-wire terminal equipment such as 500/2500 type analog phones, modems, and key systems. This card can also provide a high-voltage, low-current signal on the Tip and Ring pair of each line to light the message waiting lamp on phones equipped with that feature.

Peripheral equipment line cards

The following line cards are designed using the older Peripheral Equipment (PE) architecture. They are available to upgrade an existing system, but should not be used in new designs.

QPC192 Off-Premise Extension (OPX) Line Card

The QPC192 Off-Premise Extension (OPX) Analog Line Card is a four-channel analog line card designed to be used with 2-wire terminal equipment such as 500/2500 type analog phones, modems, and key systems. Each line supports both 600 Ω and 900 Ω line facilities. The 900 Ω impedance allows the line card to drive exceptionally long wire lengths, such as those encountered when the phone lines have to leave the building in which the Meridian 1 switch is installed. Each line also has integral hazardous and surge voltage protection to protect the Meridian 1 system from damage due to lightning strikes and accidental power line connections. This card does not support the message waiting feature.

QPC452 Basic 500/2500 Line Card

The QPC452 Basic 500/2500 Line Card is an eight-channel analog line card designed to be used with 2-wire terminal equipment such as 500/2500 type analog phones, modems, and key systems. This card does not support the message waiting feature and does not provide hazardous and surge voltage protection.

QPC578 Integrated Services Digital Line Card

The QPC578 Integrated Services Digital Line Card is an eight-channel digital line card that provides voice and data communication links between a Meridian 1 switch and modular digital telephones. Each of the eight channels supports voice-only or simultaneous voice and data service over a single twisted pair of standard telephone wire.

QPC789 16-Port Message Waiting Line Card

The QPC789 16-Port Analog Message Waiting Line Card is a 16-channel analog line card designed to be used with 2-wire terminal equipment such as 500/2500 type analog phones, modems, and key systems. This card can be programmed to provide a high-voltage, low-current signal to each line to light the message waiting lamp on phones equipped with that feature.

Installation

This section provides a high-level description of how to install and test line cards. For specific installation instructions, see *Circuit card installation and testing* (553-3001-211).

Intelligent peripheral equipment (IPE) line cards can be installed in any IPE slot of either the NT8D11 Common/Peripheral Equipment (CE/PE) Module or the NT8D37 Intelligent Peripheral Equipment (IPE) Module. [Figure 2](#) shows where an IPE line card can be installed in an NT8D11 CE/PE Module, and [Figure 3](#) shows where an IPE line card can be installed in an NT8D37 IPE Module.

Peripheral equipment (PE) line cards can be installed in any PE slot of the NT8D13 PE Module. This is shown in [Figure 4](#).

Figure 2
IPE line cards shown installed in an NT8D11 CE/PE Module

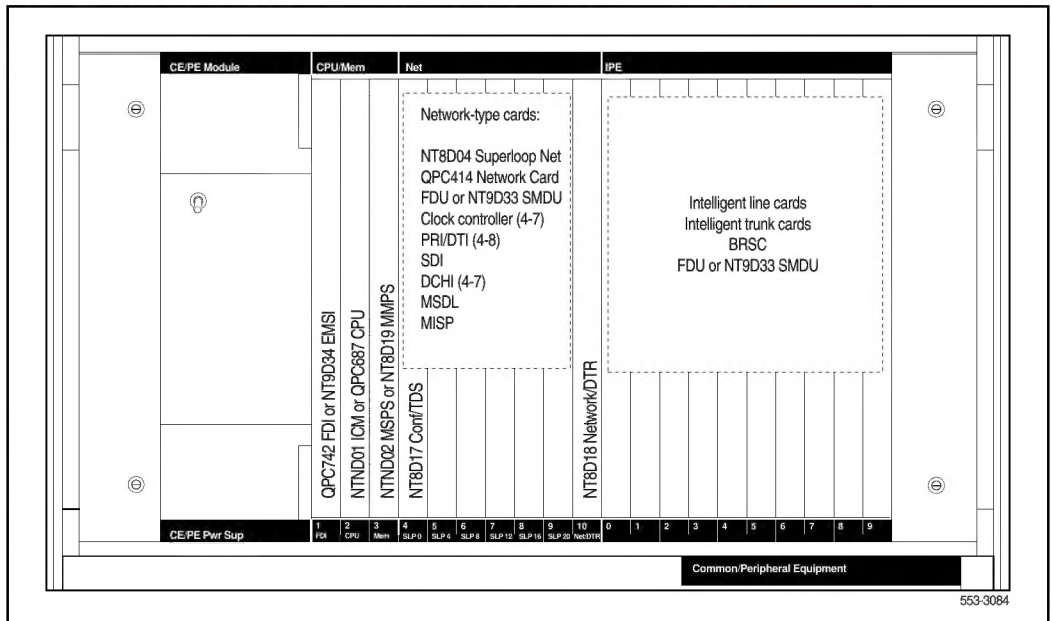


Figure 3
IPE line cards shown installed in an NT8D37 IPE Module

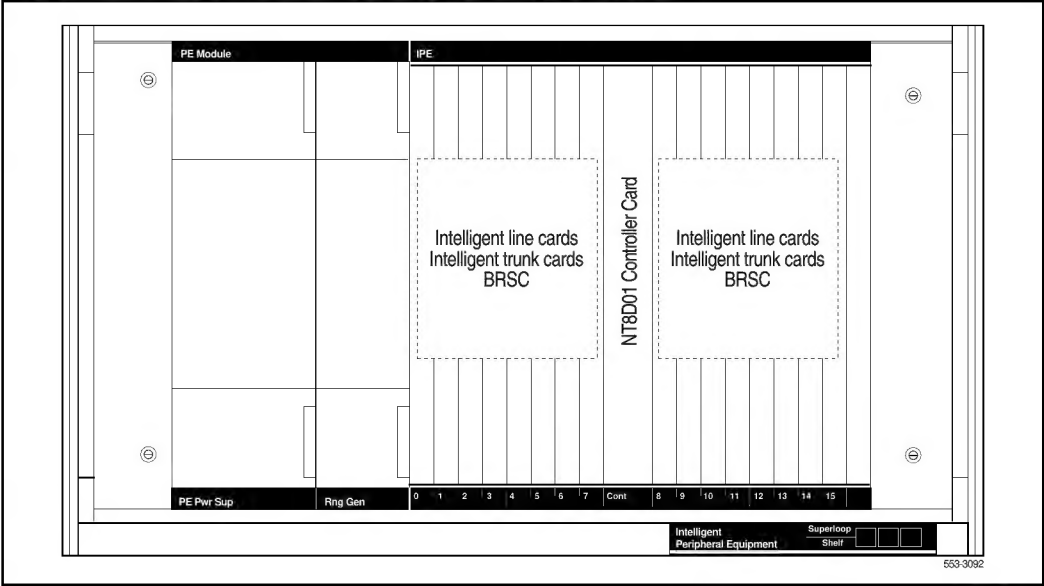
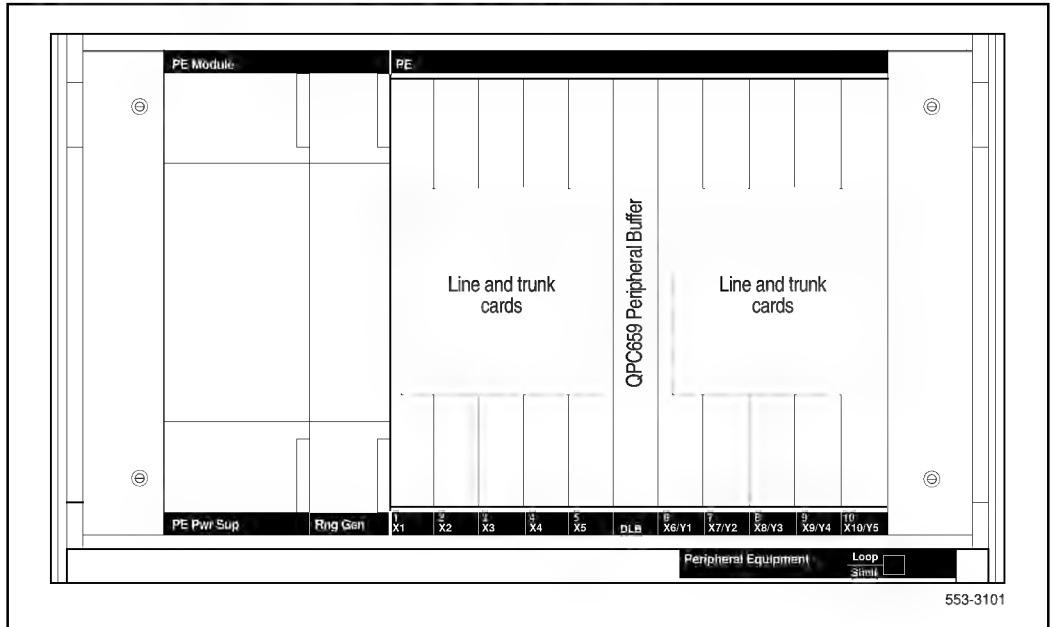


Figure 4
PE line cards shown installed in an NT8D13 PE Module



When installing line cards, these general procedures should be used:

- Configure the jumpers and switches on the line card (if any) to meet your system needs.
- Install the line card into the slot you have selected.
- Install the cable that connects the backplane connector on the PE or IPE module to the module I/O panel.
- Connect a 25-pair cable from the module I/O panel connector to the main distribution frame (MDF).
- Connect the line card output to the selected terminal equipment at the MDF.
- Configure the individual line interface unit using the Single-line Telephone Administration program (LD 10) for analog line interface units and Multi-line Telephone Administration program (LD 11) for digital line interface units.

Once these steps have been completed, the terminal equipment is ready for use.

Operation

This section describes how line cards fit into the Meridian 1 architecture, the busses that carry signals to and from the line cards, and how they connect to terminal equipment (see [Figure 5](#)). To fully understand the operation of these cards, you must understand the differences between peripheral equipment (PE) cards and intelligent peripheral equipment (IPE) cards. These differences are summarized in [Table 2](#).

Host interface bus

The original (SL-1 architecture) switches that Northern Telecom produced used a bus standard for line and trunk cards called the peripheral equipment (PE) bus. Newer switches (Meridian 1 architecture) use an improved version of this bus: the intelligent peripheral equipment (IPE) bus. Meridian 1 based switches are designed to be able to interface with the older PE based cards. This allows existing SL-1 switches to be upgraded to the Meridian 1 architecture without the expense of throwing away the existing wiring, PE modules, and line and truck cards.

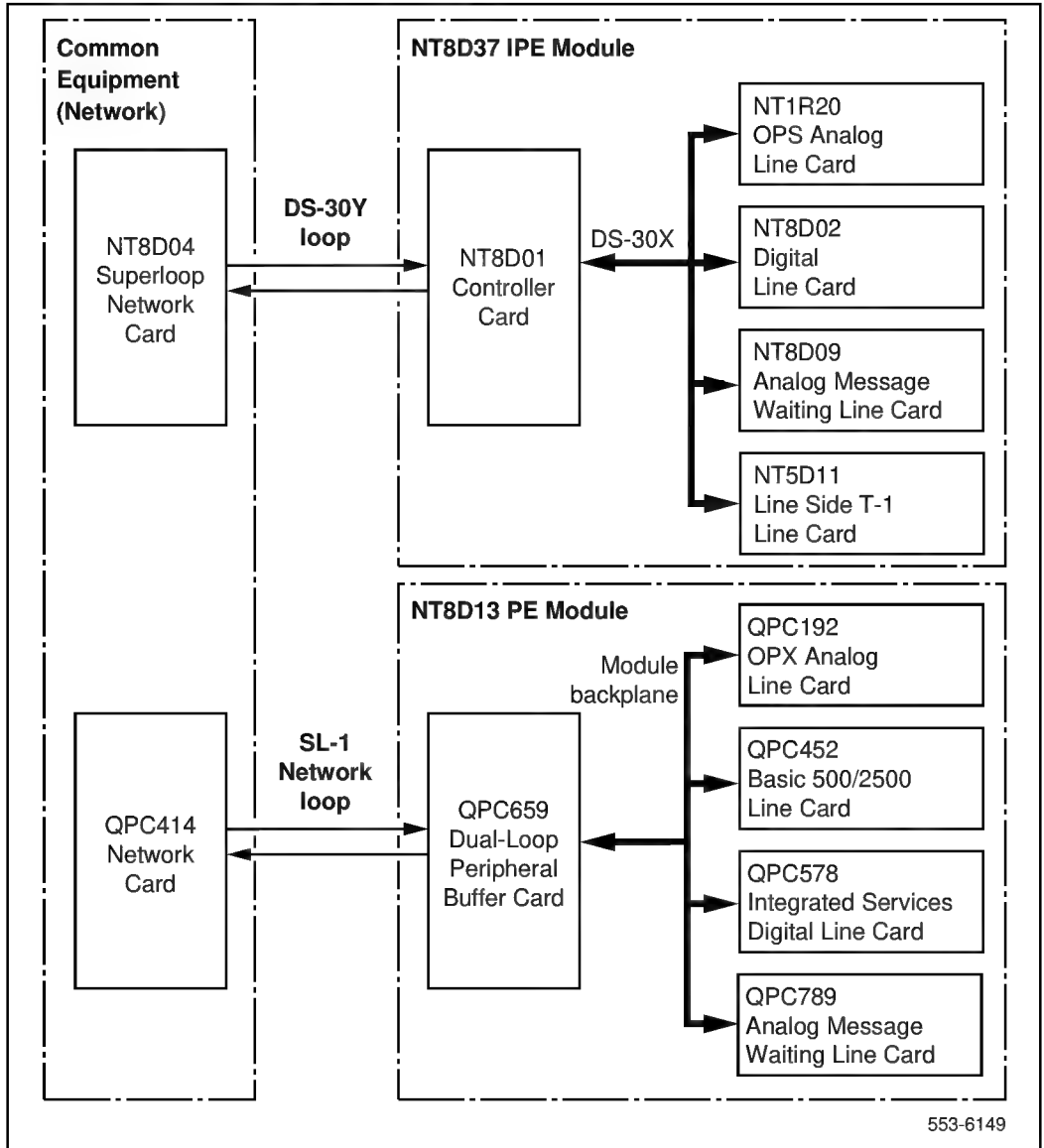
Cards based on the IPE bus have a built-in microcontroller, where cards based on the PE bus do not. The IPE microcontroller is used to perform local diagnostics (self-test), configure the card according to instructions issued by the Meridian 1 system processor, and report back to the Meridian 1 system processor information such as card identification (type, vintage, and serial number), firmware version, and programmed configuration status.

Note: IPE cards and modules should be used in all new designs. PE equipment should only be specified when upgrading an existing system.

Table 2
Differences between PE and IPE modules

Parameter	Peripheral Equipment	Intelligent Peripheral Equipment
Card Dimensions	31.75 x 25.4 x 3.6 cm. (12.5 x 10.0 x 1.4 in.)	31.75 x 25.4 x 2.2 cm. (12.5 x 10.0 x 0.875 in.)
Network Interface	SL-1 Network Loops	DS-30X Loops
Communications Interface	via the SL-1 Network Loop	card LAN Link
Microcontroller	None	8031 / 8051 Family
Peripheral Interface Card	QPC659 Dual-loop Peripheral Buffer Card	NT8D01 Controller Card
Network Interface Card	QPC414 Network Card	NT8D04 Superloop Network Card
Modules	NT8D13 PE Module	NT8D37 IPE Module NT8D11 CE/PE Module

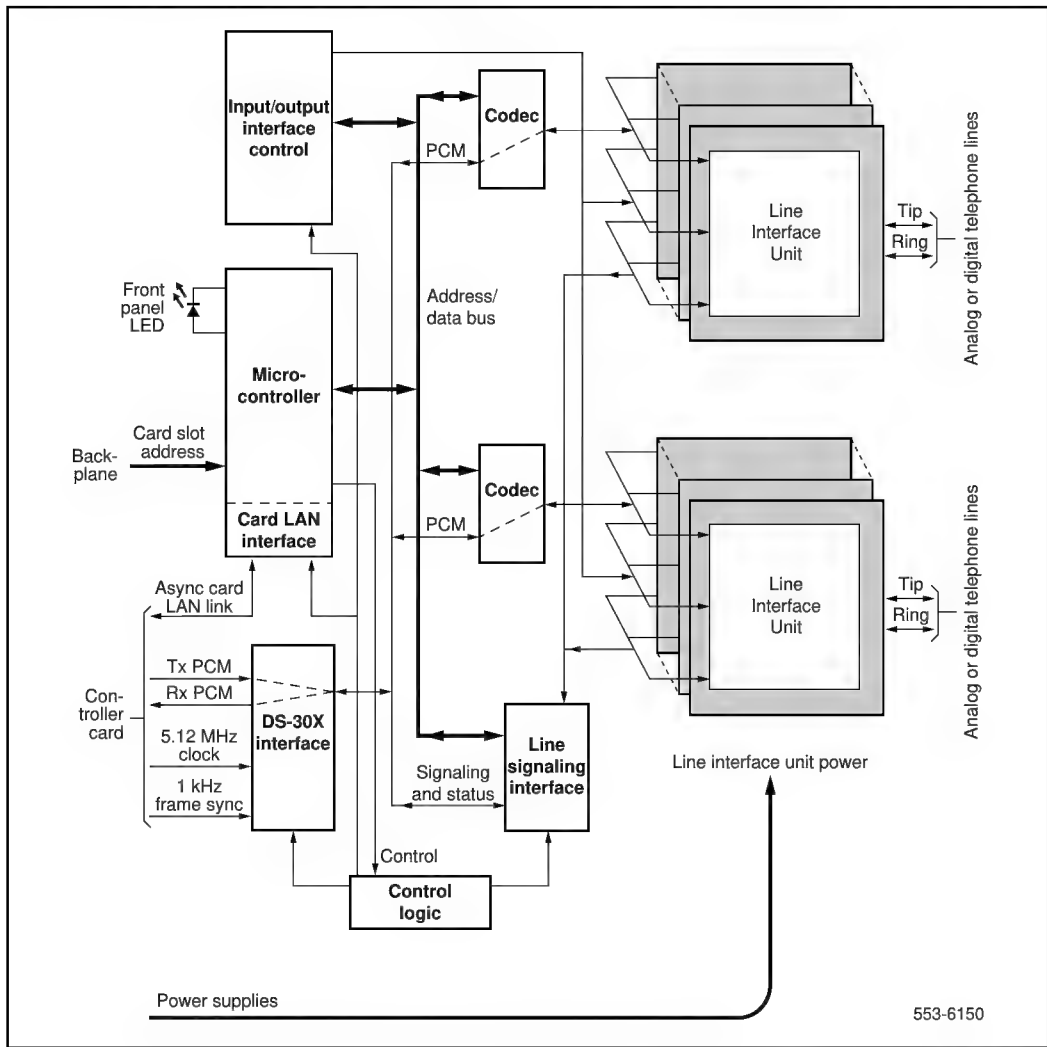
Figure 5
Network connections to PE/IPE modules



Intelligent peripheral equipment

Intelligent peripheral equipment (IPE) line cards all have a similar architecture. **Figure 6** shows a typical IPE line card architecture. The various line cards differ **only** in the number and types of line interface units.

Figure 6
Typical IPE analog line card architecture



The Meridian 1 switch communicates with IPE modules over two separate interfaces. Voice and signaling data are sent and received over DS-30X loops, and maintenance data is sent over a separate asynchronous communications link called the card LAN link.

Signaling data is information directly related to the operation of the telephone line. Signaling commands include, but are not limited to the following:

- off-hook/on-hook
- ringing signal on/off
- message waiting lamp on/off

Maintenance data is data relating to the setup and operation of the IPE card, and is carried on the card LAN link. Maintenance data includes, but is not limited to the following:

- polling
- reporting of self-test status
- CPU initiated card reset
- reporting of card ID (card type and hardware vintage)
- reporting of firmware version
- downloading line interface unit parameters
- reporting of line interface unit configuration
- enabling/disabling of the DS-30X network loop bus
- reporting of card status or T1 link status

DS-30X loops The line interfaces provided by the line cards connect to conventional 2-wire (tip and ring) line facilities. IPE analog line cards convert the incoming analog voice and signaling information to digital form and route it to the Meridian 1 common equipment (CE) CPU over DS-30X network loops. Conversely, digital voice and signaling information from the CPU is sent over DS-30X network loops to the analog line cards where it is converted to analog form and applied to the line facility.

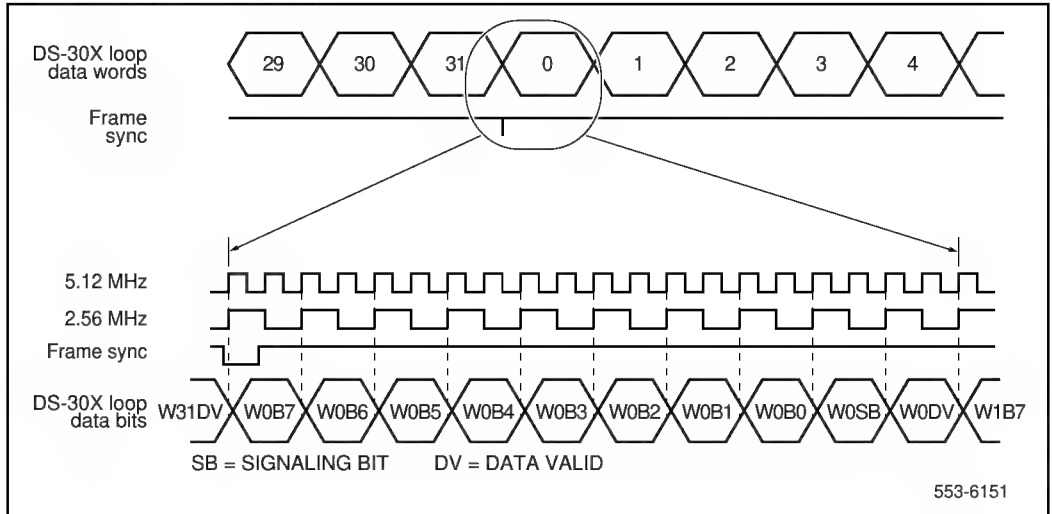
IPE digital line cards receive the data from the digital phone terminal as 512 kHz time compressed multiplexed (TCM) data. The digital line card converts that data to a format compatible with the DS-30X loop and transmits it in the next available timeslot. When a word is received from the DS-30X loop, the digital line card converts it to the TCM format and transmits it to the digital phone terminal over the digital line facility.

A separate dedicated DS-30X network loop is extended between each IPE line/trunk card and the controller cards within an IPE module (or the controller circuits on a network/DTR card in a CE/PE module). A DS-30X network loop is composed of two synchronous serial data buses. One bus transports in the transmit (Tx) direction towards the line facility and the other in the receive (Rx) direction towards the Meridian 1 common equipment.

Each bus has 32 channels for pulse code modulated (PCM) voice data. Each channel consists of a 10-bit word (see [Figure 7](#)). Eight of the 10 bits are for PCM data, one bit is the call signaling bit, and the last bit is a data valid bit. The eight-bit PCM portion of a channel is called a *timeslot*. The DS-30X loop is clocked at 2.56 Mbps (one-half the 5.12 MHz clock frequency supplied by the controller card). Thus, the timeslot repetition rate for a single channel is 8 kHz. The controller card also supplies a locally generated 1 kHz frame sync signal for channel synchronization.

Signaling data is transmitted to and from the line cards using the call signaling bit within the 10-bit channel. When the line card detects a condition that the Meridian 1 switch needs to know about, it creates a 24-bit signaling word. This word is shifted out on the signaling bit for the associated channel one bit at a time during 24 successive DS-30X frames. Conversely, when the Meridian 1 switch sends signaling data to the line card, it is sent as a 24-bit word divided among 24 successive DS-30X frames.

Figure 7
DS-30X loop data format



DS-30Y network loops extend between controller cards and superloop network cards in the common equipment and function in a manner similar to DS-30X loops (see [Figure 5](#)). Essentially, a DS-30Y loop carries the PCM timeslot traffic of a DS-30X loop. Four DS-30Y network loops form a superloop with a capacity of 128 channels (120 usable timeslots). See *Meridian 1 system engineering* (553-3001-151) for more information on superloops.

Card LAN link Maintenance communications is the exchange of control and status data between IPE line or trunk cards and the CE CPU by way of the NT8D01 Controller Card. Maintenance data is transported via the *card LAN* link. This link is composed of two asynchronous serial buses (called the Async card LAN link in [Figure 6](#)). The output bus is used by the Meridian 1 controller for output of control data to the line card. The input bus is used by the Meridian 1 controller for input of line card status data.

A card LAN link bus is common to all of the line/trunk card slots within an IPE module (or IPE section of a CE/PE module). This bus is arranged in a master/slave configuration where the controller card is the master and all other cards are slaves. The module backplane provides each line/trunk card slot with a unique hardwired slot address. This slot address enables a slave card to respond when addressed by the controller card. The controller card communicates with only one slave at a time.

In normal operation, the controller card continually scans (polls) all of the slave cards connected to the card LAN to monitor their presence and operational status. The slave card sends replies to the controller on the input bus along with its card slot address for identification. In this reply, the slave informs the controller if any change in card status has taken place. The controller can then prompt the slave for specific information. Slaves only respond when prompted by the controller; they do not initiate exchange of control or status data on their own.

When an IPE line card is first plugged into the backplane, it runs a self-test. When the self-test is completed, a properly functioning card responds to the next controller card poll with the self-test status. The controller then queries for card identification and other status information. The controller then downloads all applicable configuration data to the line card, initializes it, and puts it into an operational mode.

Peripheral equipment

Peripheral equipment (PE) line cards all have a similar architecture (shown in [Figure 8](#)). The various line cards differ only in the number and types of line interface units.

Peripheral equipment (PE) line cards are not intelligent cards, but rather must work in conjunction with a QPC659 Dual-Loop Peripheral Buffer Card (see [Figure 5](#)). The peripheral buffer card generates two sets of “card select” signals. A separate card enable signal is generated for each card slot in the PE backplane. A four-bit encoded line address is used to select an individual line interface unit upon that card (see [Table 3](#)).

The peripheral buffer card maintains a table of which line card and line unit address is assigned to a particular timeslot in the SL-1 network loop. It uses that information to generate the card enable and line address signals at the proper time.

A line unit is enabled by the simultaneous occurrence of a card enable signal for the card that it resides on and a line address that corresponds to the address of the line unit appearing on the line address bus. When these conditions occur, the data that is present on the SL-1 network loop at that time is written to and read from the line unit codec.

Figure 8
Typical PE line card architecture

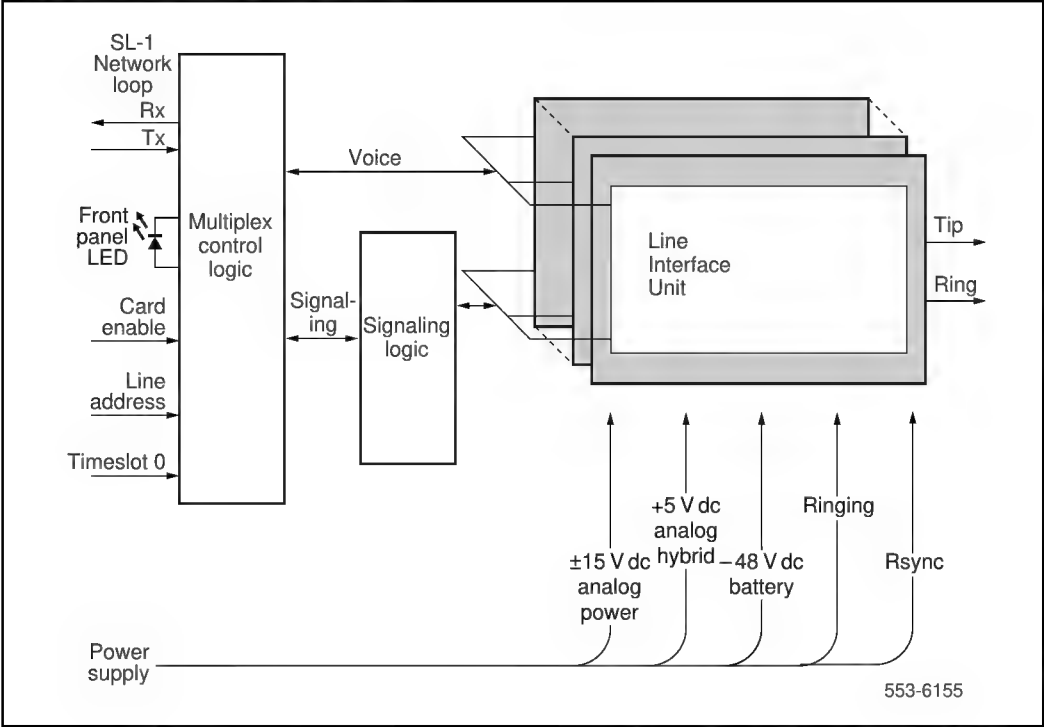


Table 3
Line unit address decoding

Line Unit Select Address				Line Interface Unit	Signals used by:		
-ADD3	-ADD2	-ADD1	-ADD0				
1	1	1	1	0	Single Density Cards	Dual Density Cards	Quad Density Cards
1	1	1	0	1			
1	1	0	1	2			
1	1	0	0	3			
1	0	1	1	4			
1	0	1	0	5			
1	0	0	1	6			
1	0	0	0	7			
0	1	1	1	8			
0	1	1	0	9			
0	1	0	1	10			
0	1	0	0	11			
0	0	1	1	12			
0	0	1	0	13			
0	0	0	1	14			
0	0	0	0	15			
Note: Single density line cards have either two or four line units per card. Dual density line cards have eight line units per card. Quad density line cards have 16 line units per card.							

SL-1 Network loops The line interfaces provided by the line cards connect to conventional 2-wire (tip and ring) line facilities. Peripheral equipment (PE) analog line cards convert the incoming analog voice and signaling information to digital form and route it to the Meridian 1 common equipment (CE) CPU over SL-1 network loops. Conversely, digital voice and signaling information from the CPU is sent over SL-1 network loops to the analog line cards where it is converted to analog form and applied to the line facility.

PE digital line cards receive the data from the digital phone terminal as 512 kHz time compressed multiplexed (TCM) data. The digital line card converts that data to a format compatible with the SL-1 Network loop, and transmits it in the next available timeslot. When a word is received from the SL-1 Network loop, the digital line card converts it to the TCM format and transmits it to the digital line facility.

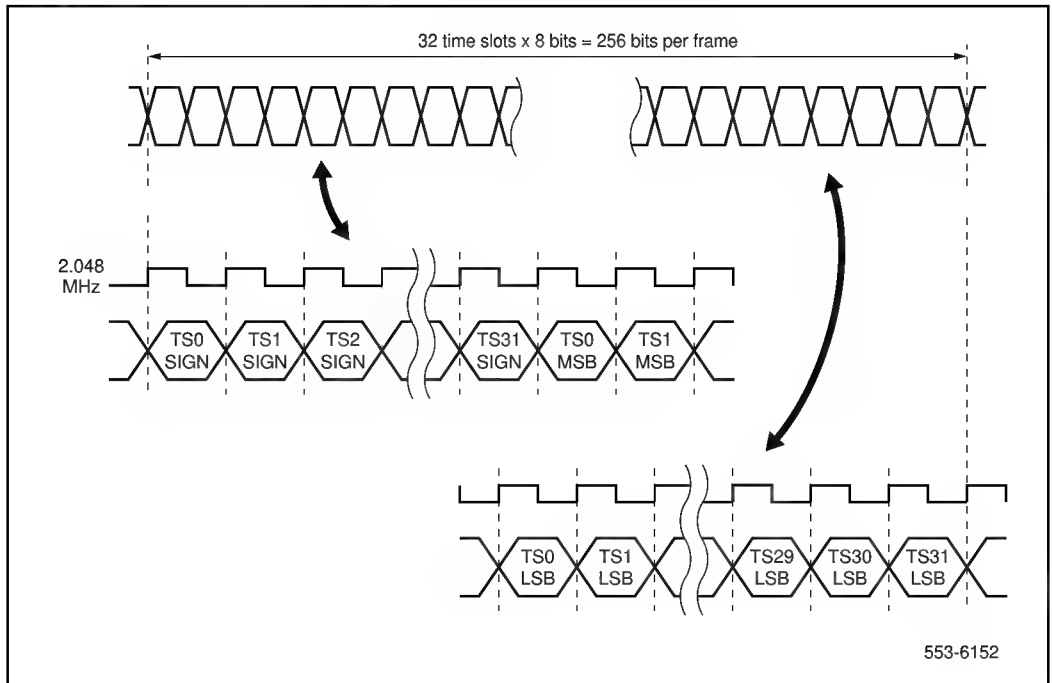
Each loop has 32 timeslots for pulse code modulated (PCM) data. Each of the 32 channels is carried at 64 kbps (the standard rate for a digitized voice channel). The total data rate is therefore 2.048 Mbps.

Data on the loop is “bit-interleaved” instead of byte-interleaved as it is on the DS-30X loop. Instead of having a byte of data occupy eight successive timeslots on the loop, the SL-1 Network loop has the first 32 successive timeslots occupied (in order) by the sign bit from each channel. The next 32 successive timeslots are occupied by the most significant bit (MSB), and so on, until eight “subframes” of 32 timeslots each have been completed (see [Figure 9](#)).

An SL-1 Network loop is composed of two synchronous serial data buses. One bus transports in the transmit (Tx) direction towards the line facility and the other in the receive (Rx) direction towards the Meridian 1 common equipment. When a terminal is enabled during a timeslot, its codec transmits one bit of PCM data towards the Meridian 1 CE and, at the same time, receives one bit of data from the Meridian 1 CE.

The timeslots are numbered 0 through 31. Timeslot 0 is reserved for signaling information. Timeslot 1 is not used. Timeslots 2 through 31 are used for voice data, giving a total of 30 usable timeslots for voice.

Figure 9
SL-1 Network loop data format



SL-1 Network loop signaling SL-1 Network loop signaling is used to send messages to and receive messages from the peripheral equipment cards. A typical message to the PE card directs the card to enable the front panel fault LED, enable ringing onto a particular line, or light the message waiting lamp for a particular line. A typical message from the PE card tells the system processor that a line has gone off hook.

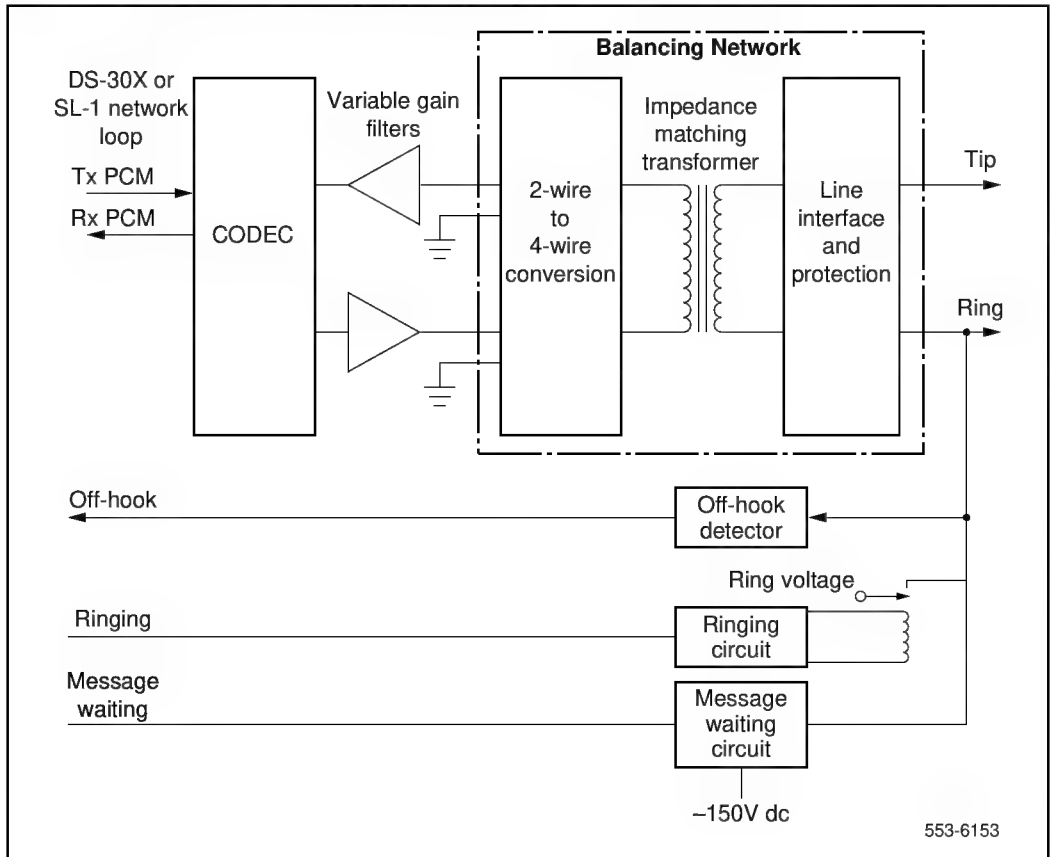
Messages are sent and received during timeslot zero. An enable signal TS0 (timeslot zero enable) is generated during each timeslot zero. When the network card has a message for a particular peripheral card, it asserts the card enable signal for that card along with the TS0 signal. This continues on successive TS0s until a complete message has been sent.

The network card regularly polls the PE cards during TS0 to see if any of them has a message to be sent. When a PE card has a message waiting, it responds to the poll by sending a series of ones during the next five successive timeslot zeros. The network card responds by sending a “message send enable” message (all 1s). The PE card replies by sending 1, 1, 1, 0, and then the message in successive timeslot zeros.

Analog line interface units

Once the 8-bit digital voice signal has been received by the analog line card, it must be converted back into an analog signal, filtered, converted from a 4-wire transmission path to a 2-wire transmission path, and driven onto the analog telephone line. [Figure 10](#) shows a typical example of the logic that performs these functions. Each part of the analog line interface unit is discussed in the following section.

Figure 10
Typical analog line interface unit block diagram



Coder/Decoder circuit The Coder/Decoder (codec) performs analog to digital (A/D) and digital to analog (D/A) conversion of the line analog voiceband signal to and from a digital PCM signal. This signal can be coded and decoded using either the A-Law or the μ -Law companding algorithm. On some analog line cards the decoding algorithm depends of the type of codec installed when the board is built. On others, it is an option selected using a software overlay.

Variable gain filters Audio signals received from the analog phone line are passed through a low-pass Analog to Digital (A/D) monolithic filter that limits the frequency spread of the input signal to a nominal 200 to 3400 Hz bandwidth. The audio signal is then applied to the input of the codec. Audio signals coming from the codec are passed through a low-pass A/D monolithic filter that integrates the amplitude modulated pulses coming from the codec, and then filters and amplifies the result. On some of the line cards, the gain of these filters can be programmed by the system controller. This allows the system to make up for line losses according to the loss plan.

Balancing network Depending on the card type, the balancing network provides a 600 Ω , 900 Ω , 3COM or 3CM2 impedance matching network. It also converts the 2-wire transmission path (tip and ring) to a 4-wire transmission path (Rx/ground and Tx/ground). The balancing network is usually a transformer/analog (hybrid) circuit combination, but can also be a monolithic subscriber line interface circuit (SLIC) on the newer line cards.

Line interface and foreign voltage protection The line interface unit connects the balancing network to the telephone tip and ring pairs. The off-premise line card (NT1R20) has circuitry that protects the line card from foreign voltage surges caused by inadvertent power line connections and lightning surges. This protection is necessary whenever the telephone line leaves the building where the switch is installed.

The line interface unit ([Figure 10](#)) has a relay that applies the ringing voltage onto the phone line. The RSYNC signal from the 20 Hz (nominal) ringing voltage power supply is used to prevent switching of the relay during the current peak. This eliminates switching glitches and extends the life of the switching relay.

The off-hook detection circuit monitors the current draw on the phone line. When the current draw exceeds a preset value, the circuit generates an off-hook signal that is transmitted back to the system controller.

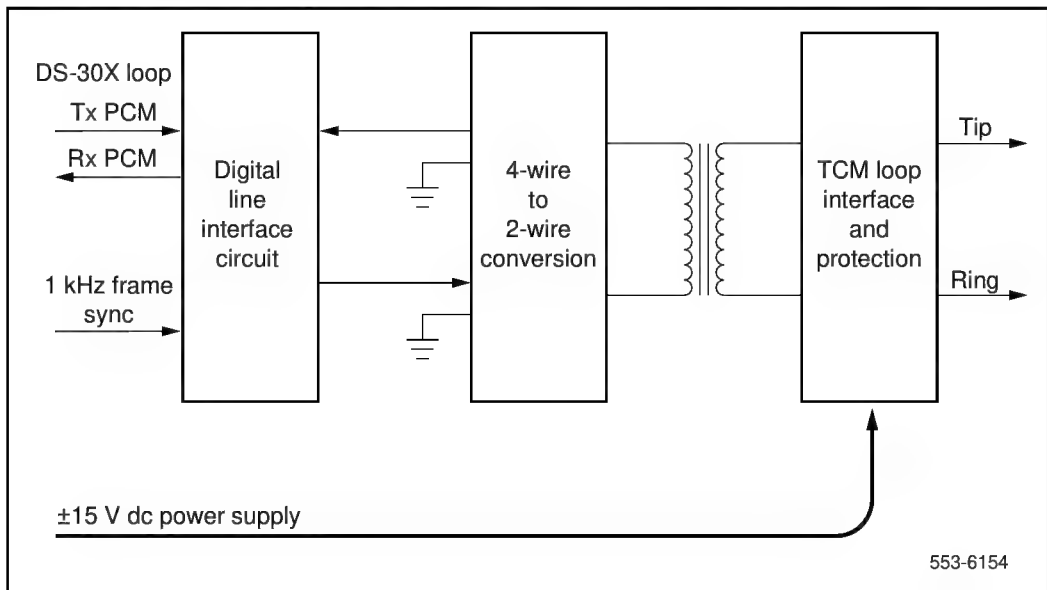
The message waiting circuit on message waiting line cards monitors the status of the message waiting signal and applies –150 V dc power to the tip lead when activated. This voltage is used to light the message waiting lamps on phones that are equipped with that feature. The high voltage supply is automatically disconnected when the phone goes off-hook. Later line cards are able to sense when the message waiting lamp is not working and can then report that information back to the system controller.

Digital line interface units

The NT8D02 and QPC578 digital line cards provide voice and data communication links between a Meridian 1 switch and modular digital telephones. These lines carry multiplexed PCM voice, data and signaling information as time compression multiplexed (TCM) loops. Each TCM loop can be connected to a Northern Telecom “Meridian Modular Digital” telephone set.

The digital line interface card contains one or more digital line interface units (Figure 11). Each digital line interface unit contains a digital line interface circuit (DLIC). The purpose of each digital line interface circuit is to demultiplex data from the DS-30X Tx channel into integrated voice and data bitstreams and transmit those bitstreams as Bi-Polar Return to Zero, Alternate Mark Inversion (BPRZ-AMI) data to the TCM loop. It also does the opposite: receives BPRZ-AMI bitstreams from the TCM loop and multiplexes the integrated voice and data bitstream onto the DS-30X Rx channel.

Figure 11
Digital line interface unit block diagram



The 4-wire to 2-wire conversion circuit converts the 2-wire tip and ring leads into a 4-wire (Tx and ground and RX and ground) signal that is compatible with the digital line interface circuit.

TCM loop interfaces

Each digital phone line terminates on the digital line card at a TCM loop interface circuit. The circuit provides transformer coupling and foreign voltage protection between the TCM loop and the digital line interface circuit. It also provides power for the digital telephone set.

To prevent undesirable side effects from occurring when the TCM loop interface cannot provide the proper signals on the digital phone line, the system controller can remove the ± 15 V dc power supply from the TCM loop interface. This happens when either the card gets a command from the NT8D01 Controller Card to shut down the channel or the digital line card detects a loss of the 1 KHz frame synchronization signal.

Each TCM loop interface circuit can service loops up to 3500 ft. in length when using 24 gauge wire. The circuit allows for a maximum AC signal loss of 15.5 dB at 256 KHz and a maximum DC loop resistance of 210 ohms.

Signaling

The digital line interface units also contain signaling and control circuits that establish, monitor, and take down call connections. These circuits work with the system controller to operate the digital line interface circuits during calls. The circuits receive outgoing call signaling messages from the controller and return incoming call status information to the controller over the DS-30X network loop.

Analog line call operation

The applications, features, and signalling arrangements for each line interface unit are configured in software and implemented on the card through software download messages. When an analog line interface unit is idle, it provides a voltage near ground on the tip lead and a voltage near -48 V dc on the ring lead to the near-end station. (The near-end station is the telephone or device that is connected to the analog line card by the tip and ring leads.) An on-hook telephone presents a high impedance toward the line interface unit on the card.

Incoming calls

Incoming calls to a telephone that is connected to an analog line card can originate either from stations that are local (served by the Meridian 1 PBX), or remote (served through the public switched telephone network). The alerting signal to a telephone is 20 Hz (nominal) ringing. When an incoming call is answered by the near-end station going off-hook, a low-resistance DC loop is placed across the tip and ring leads (towards the analog line card) and ringing is tripped (see [Figure 12](#)).

Outgoing calls

For outgoing calls from the near-end station, a line interface unit is seized when the station goes off-hook, placing a low-resistance loop across the tip and ring leads towards the analog line card (see [Figure 13](#)). When the card detects the low-resistance loop, it prepares to receive digits. When the Meridian 1 is ready to receive digits, it returns dial tone. Outward address signaling is then applied from the near-end station in the form of loop (interrupting) dial pulses or DTMF tones.

Message waiting

Line cards that are equipped with the message waiting feature receive notification that a message is waiting across the Card LAN link (IPE cards) or the SL-1 network loop (PE cards). On cards that drive a message waiting light, the light is turned on by connecting the ring side of the telephone line to the -150 V dc power supply. When the line card senses that the telephone has gone off-hook, it removes the -150 V dc voltage until the telephone goes back on-hook. Line cards that use an interrupted dial tone to indicate message waiting do nothing until the receiver is picked up. The line card then interrupts the dial tone at a regular interval to indicate that a message is waiting.

Figure 12
Call connection sequence—near-end station receiving call

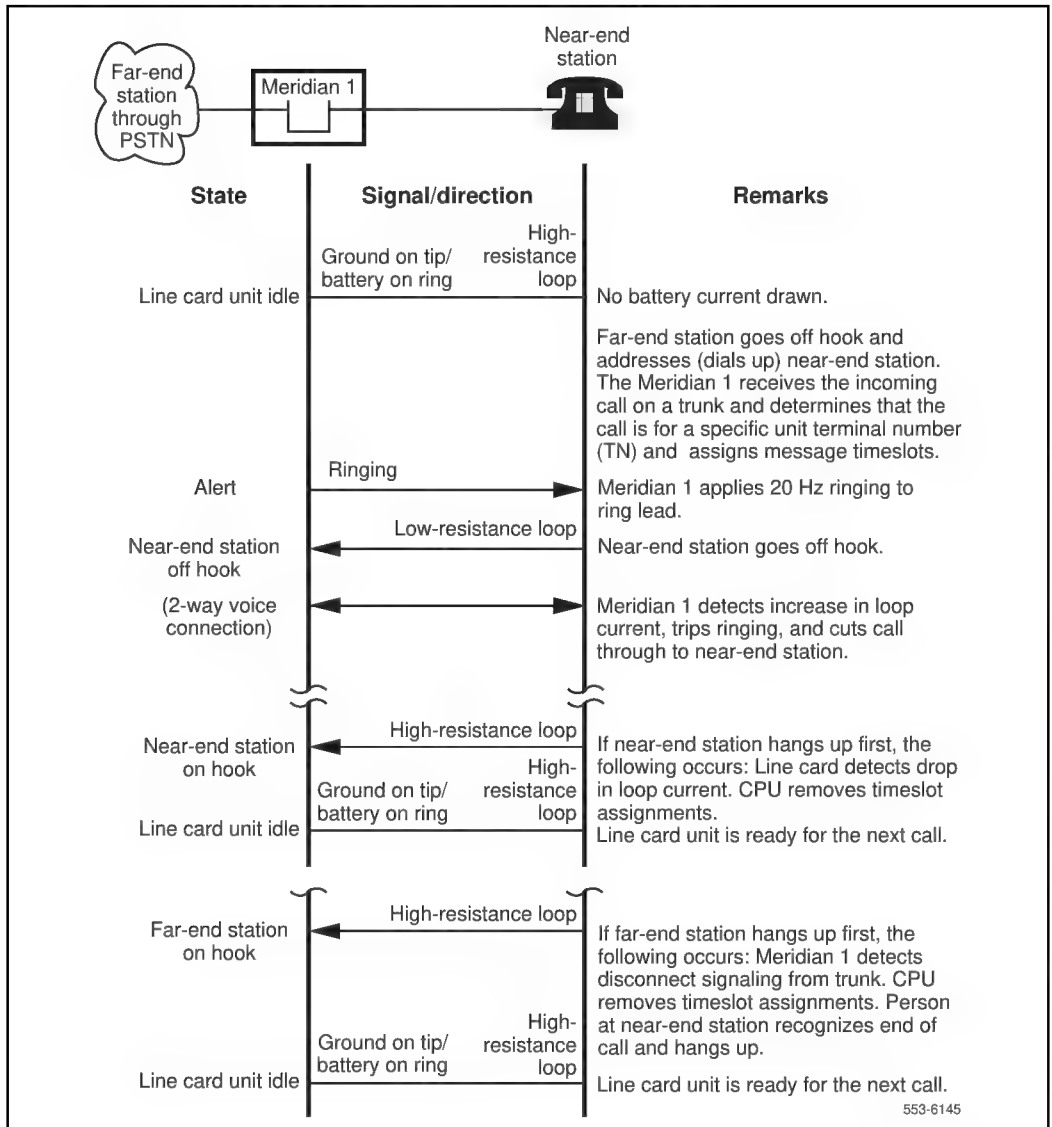
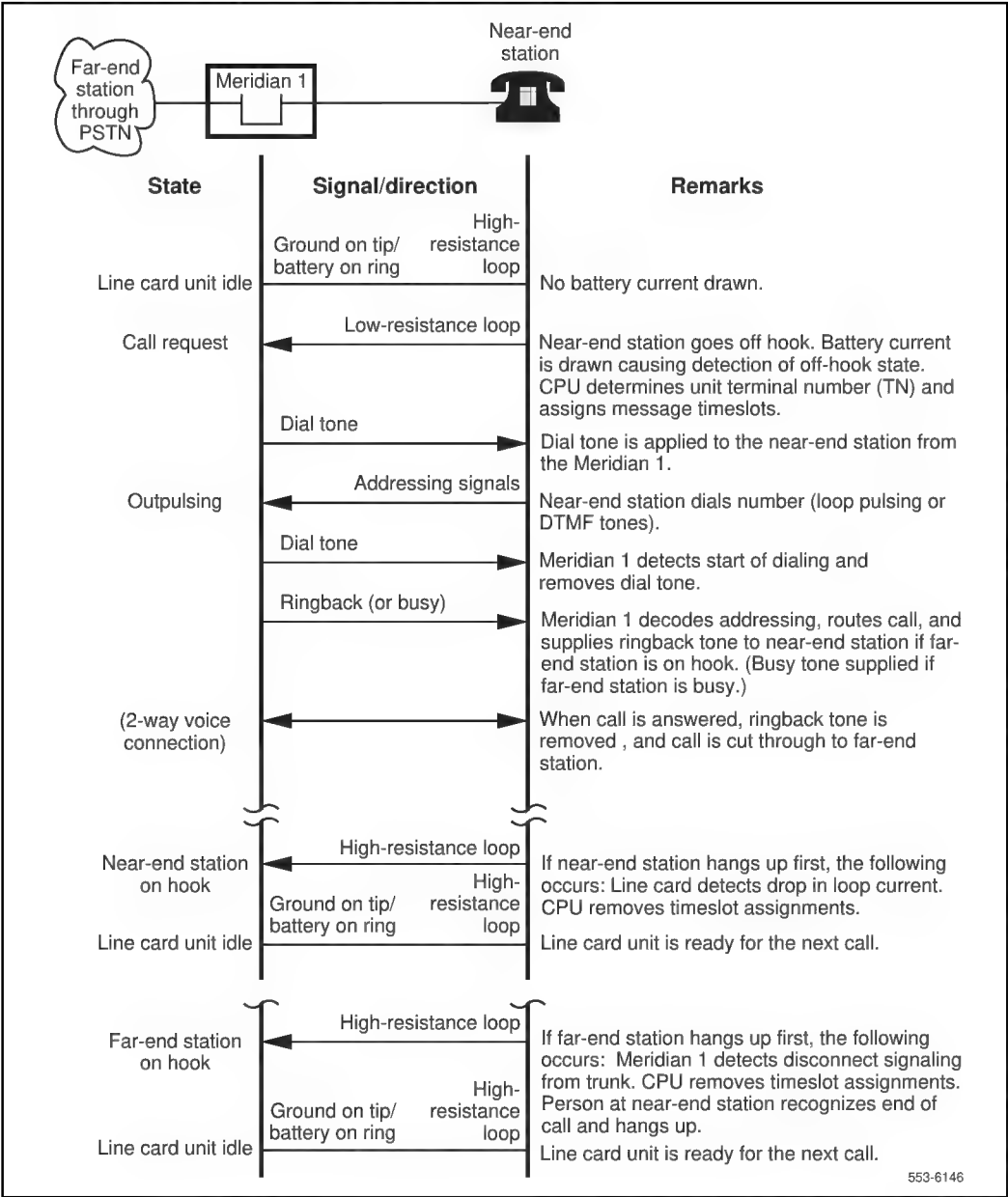


Figure 13
Call connection sequence—near-end originating call



In both cases, the message waiting indication will continue until the user checks his or her messages. At that time, the Meridian 1 system will cancel the message waiting indication by sending another message across the Card LAN link or SL-1 network loop.

Analog line supervision

Analog line supervision features are used to extend the answer supervision and disconnect supervision signals when the line card is connected to an intelligent terminal device (Key system or intelligent pay phone). Two types of analog line supervision are provided, *battery reversal answer and disconnect supervision*, and *hook flash disconnect supervision*.

Note: Analog Line Supervision features are only supported on Meridian 1 processors that are running Release 21 software (or greater).

Battery reversal answer and disconnect supervision Battery reversal answer and disconnect supervision is only used for calls that originate from the terminal device. It provides both far-end answer supervision and far-end disconnect supervision signals to the terminal device. In an intelligent pay phone application, these signals provide the information necessary to accurately compute toll charges.

In the idle state, and during dialing and ringing at the far end, the line card provides a ground signal on the tip lead and battery on the ring lead (see [Figure 14](#)). When the far-end answers, these polarities are reversed. The reversed battery connection is maintained as long as the call is established. When the far-end disconnects, the Meridian 1 system sends a message that causes the line card to revert the battery and ground signals to the normal state to signal that the call is complete.

Hook Flash disconnect supervision Hook flash disconnect supervision is only used for incoming calls that terminate at the terminal device (typically a Key system), see [Figure 15](#). The disconnect signal is indicated by the removal of the ground connection to the tip lead for a specific period of time. The period of time is programmable using LD10, and ranges from a minimum of 10 milliseconds to a maximum of 2.55 seconds. See the *X11 input/output guide* (553-3001-400) for more information.

Figure 14
Battery reversal answer and disconnect supervision sequence

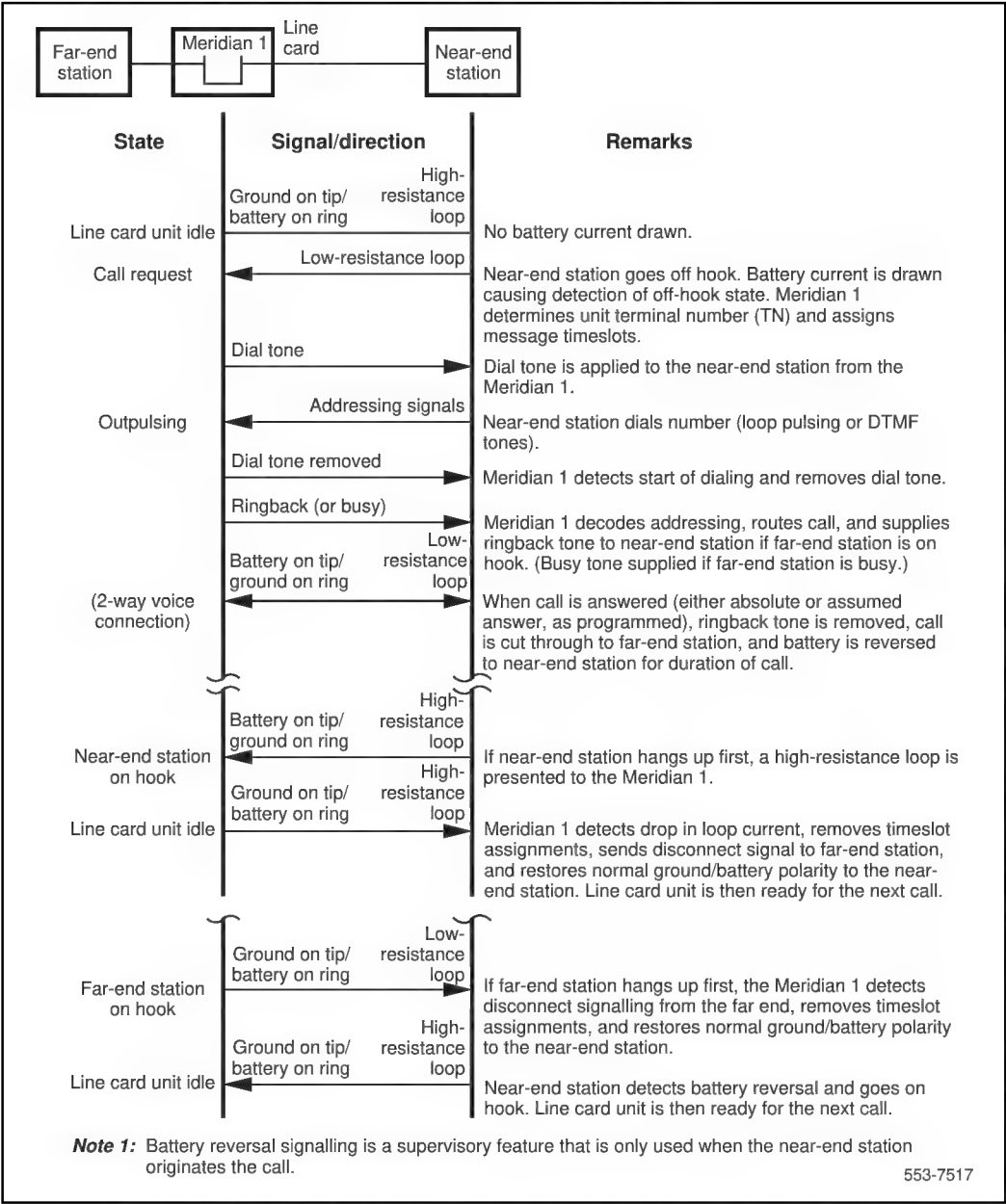
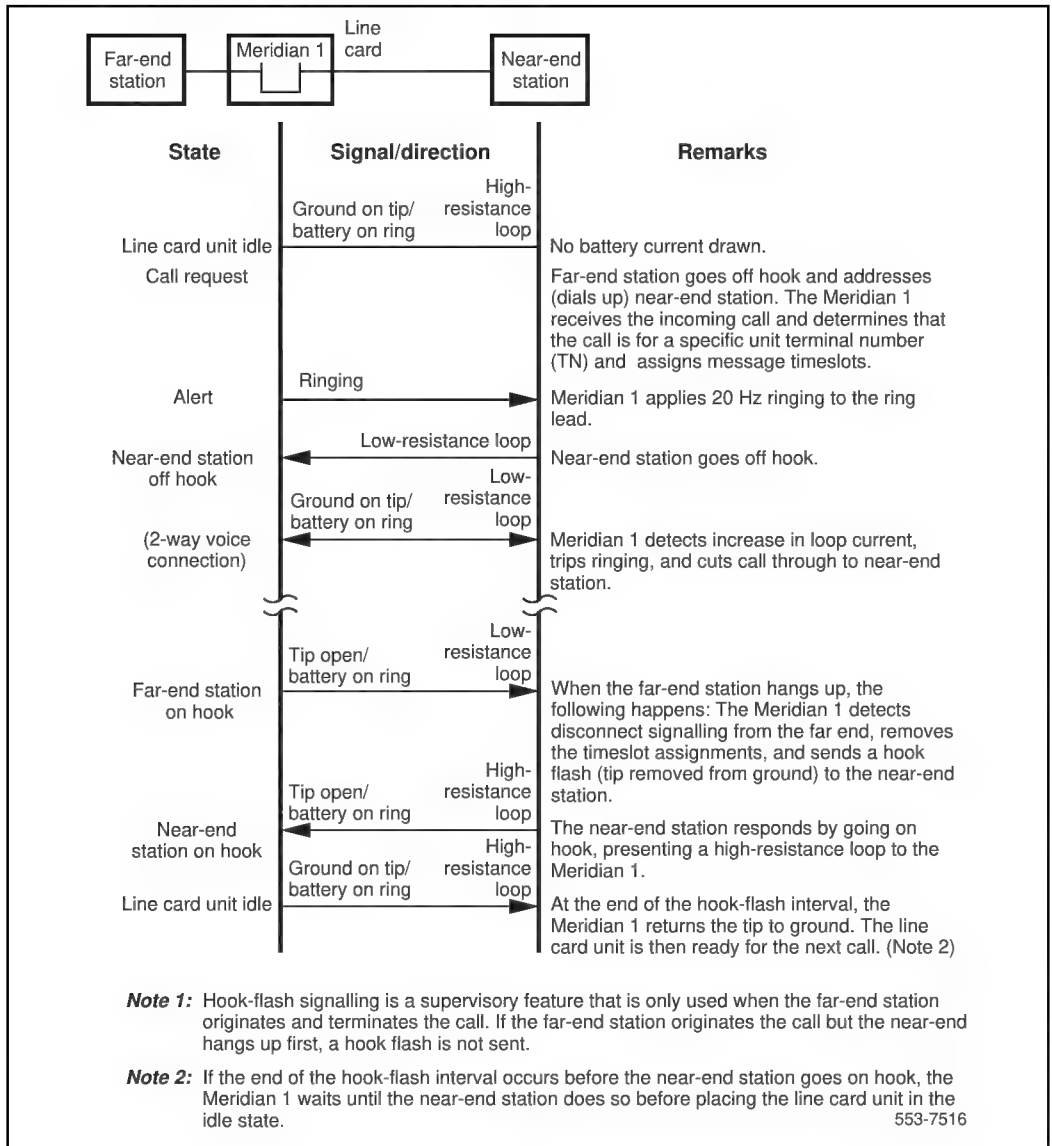


Figure 15
Hook flash disconnect supervision sequence



Digital line call operation

Digital line call operation is controlled entirely by use of messages between the digital telephone set and the Meridian 1 system. These messages are carried across the TCM loop interface. There is no call connection sequence similar to the one used for analog telephone line operation.

Line-side T1 call operation

The line-side T1 card's call operation is performed differently depending on whether the T1 link is configured to process calls in *loop start* mode or *ground start* mode. Configuration is performed through dip switch settings on the line-side T1 card (see "Installation and Configuration" on page 87 for more information on dip switch settings).

The line-side T1 card performs calls processing separately on each of its 24 channels. Signaling is performed using the "A/B robbed bit" signaling standard for T1 communication. A/B robbed bit signaling simulates standard analog signaling by sending a meaningful combination of ones and zeros across the line that correlates to the electrical impulses that standard analog signaling sends. For example, to represent that an analog line interface unit is idle, the analog line card provides a ground on the tip lead and -48Vdc on the ring lead. The line-side T1 card accomplishes the same result by sending its A bit as 0 (translated as ground on the tip lead) and its B bit as 1 (translated as -48Vdc on the ring lead). However, measuring the voltage of the ring lead on the T1 line would not return -48Vdc, since actual electrical impulses are not being sent.

Call operation will be described by categorizing the operation into the following main states:

- Idle (on-hook)
- Incoming calls
- Outgoing calls
- Calls disconnected by the Central Office (CO)
- Calls disconnected by the telephone

Loop Start Mode

In Loop Start mode, the A and B bits have the following meaning:

Transmit from LTI: A bit = 0 (tip ground on)
B bit = Ringing (0=on, 1=off)

Receive to LTI: A bit = Loop (0=open, 1=closed)
B bit = 1 (no ring ground)

When a T1 channel is idle, the line-side T1 card simulates a ground on the tip lead and -48Vdc on the ring lead to the terminal equipment by setting its transmit A bit to 0 and transmit B bit to 1. Accordingly, an on-hook channel on the terminal equipment simulates an open loop toward the line-side T1 card, causing the line-side T1 card's receive bits to be set to A = 0 and receive B = 1.

Incoming calls Incoming calls to terminal equipment attached to the line-side T1 card can originate either from stations that are local (served by the Meridian 1 PBX), or remote (served through the public switched telephone network). To provide the ringing signal to a telephone the line-side T1 card simulates an additional 90V on the ring lead to the terminal equipment by alternating the transmit B bit between 0 and 1 (0 during ring on, 1 during ring off). When an incoming call is answered by the terminal equipment going off-hook, the terminal equipment simulates tripping the ringing and shutting off ringing, causing the line-side T1 card's receive A bit to be changed from 0 to 1.

Outgoing calls During outgoing calls from the terminal equipment, a channel is seized when the station goes off-hook. This simulates a low-resistance loop across the tip and ring leads toward the line-side T1 card, causing the line-side T1's receive A bit to be changed from 0 to 1. This bit change prepares the line-side T1 to receive digits. Outward address signaling is then applied from the terminal equipment in the form of DTMF tones or loop (interrupting) dial pulses that are signaled by the receive A bit pulsing between 1 and 0.

Call disconnect from far end (PSTN, private network or local Station)

When a call is in process, the central office may disconnect the call from the Meridian 1. If the line-side T1 port has been configured with the supervised analog line (SAL) feature, the line-side T1 card will respond to the distant end disconnect message by momentarily changing its transmit A bit to 1 and then returning it to 0. The duration of time that the transmit A bit remains at 1 before returning to 0 depends upon the setting that was configured using the SAL. If the terminal equipment is capable of detecting distant end disconnect, it will respond by changing the line-side T1 card's receive A bit to 0 (open loop). The call is now terminated and the interface is in the idle (on-hook) state.

For the line-side T1 card to support distant end disconnect in loop start mode, the following configuration parameters must exist:

- X11 software release 21 or later is required and the Supervised Analog Line (SAL) feature must be configured for each line-side T1 port.

Note: By default, the SAL feature opens the tip side for 750 m/s in loop start operation. This is configurable in 10 m/s increments.

- For outgoing trunk calls, the trunk facility must provide far end disconnect supervision.
- In order to detect distant end disconnect for calls originating on the line-side T1 card, the battery reversal feature within the SAL software must be enabled. Enabling the battery reversal feature will not provide battery reversal indication but will only provide a momentary interruption of the tip ground by asserting the A bit to 1 for the specified duration.
- In order to detect distant end disconnect for calls terminating on the line-side T1 card, the hook flash feature within the SAL software must be enabled.
- In order to detect distant end disconnect for calls originating and terminating on the line-side T1 card, both the battery reversal and hook flash features must be enabled within the SAL software.

Call disconnect from line-side T1 terminal equipment Alternatively, while a call is in process, the terminal equipment may disconnect by going on-hook. The terminal equipment detects no loop current and sends signaling to the line-side T1 card that causes its receive A bit to change from 1 to 0. The call is now released.

[Table 4](#) outlines the line-side T1's A and B bit settings in each state of call processing.

Ground Start Mode

In ground start mode, the A and B bits have the following meaning:

Transmit from LTI: A bit = Tip ground (0=grounded, 1=not grounded)
B bit = Ringing (0=on, 1=off)

Receive to LTI: A bit = Loop (0=open, 1=closed)
B bit = Ring ground (0=grounded, 1=not grounded)

When a T1 channel is idle, the line-side T1 card simulates a ground on the tip lead and -48Vdc on the ring lead to the terminal equipment by setting the transmit A bit to 1 and transmit B bit to 1. Accordingly, an on-hook telephone simulates an open loop toward the line-side T1 card, causing the line-side T1 card's receive bits to be set to A = 0 and B = 1.

Incoming Calls Incoming calls to terminal equipment that is connected to the line-side T1 card can originate either from stations that are local (served by the Meridian 1 PBX), or remote (served through the public switched telephone network). To provide the ringing signal to the terminal equipment the line-side T1 card simulates the 90V ring signal on the ring lead by alternating the transmit B bit between 0 and 1 (0 during ring on, 1 during ring off), and ground on the tip lead by setting the transmit A bit to 0. When an incoming call is answered (by the terminal equipment going off-hook), the terminal equipment simulates tripping the ringing and shutting off ringing by causing the line-side T1's receive A bit to change from 0 to 1. The line-side T1 card responds to this message by simulating loop closure by holding the transmit B bit constant at 1.

Table 4
Loop Start Call Processing A/B Bit Settings

State	Transmit		Receive	
	A	B	A	B
Idle	0	1	0	1
Incoming Calls:				
— Idle	0	1	0	1
— Ringing is applied from line-side T1 card	0	1/0	0	1
— Terminal equipment goes off-hook	0	1/0	1	1
— Line-side T1 card stops ringing	0	1	1	1
Outgoing Calls:				
— Idle	0	1	0	1
— Terminal equipment goes off-hook	0	1	1	1
Call Disconnect from far end:				
— Steady state (call in progress)	0	1	1	1
— Far end disconnects by dropping loop current and line-side T1 card changes Transmit A bit to 1 momentarily.	1	1	1	1
— Terminal equipment responds causing Receive A bit to change to 0.	1	1	0	1
— Line-side T1 responds by changing its Transmit A bit to 0. Call is terminated and set to idle state.	0	1	0	1
Call disconnect from terminal equipment:				
— Steady state (call in progress)	0	1	1	1
— Terminal equipment goes on-hook causing the Receive A bit to change to 0. Call is terminated and set to idle state.	0	1	0	1

Outgoing Calls During outgoing calls from the terminal equipment, a channel is seized when the terminal equipment goes off-hook, simulating a ground to the ring lead toward the line-side T1 card by causing the line-side T1's receive B bit to change from 1 to 0. In turn, the line-side T1 card simulates grounding its tip lead by changing the transmit A bit to 0. The terminal equipment responds to this message by removing the ring ground (line-side T1's receive B bit is changed to 1) and simulating open loop at the terminal equipment (line-side T1's receive A bit is changed to 0).

Call disconnect from far end (PSTN, private network or local station

While a call is in process, the far end may disconnect the call. If the line-side T1 port has been configured with the supervised analog line (SAL) feature, the line-side T1 will respond to the distant end disconnect message by opening tip ground. This causes the line-side T1 card to change the transmit A bit to 1. When the terminal equipment sees the transmit A bit go to 1, it responds by simulating open loop causing the line-side T1's receive A bit to change to 0. The call is terminated and the interface is once again in the idle condition.

For the line-side T1 card to support distant end disconnect in ground start mode, the following configuration parameters must exist:

- X11 software release 21 or later is required and the Supervised Analog Line (SAL) feature must be configured for each line-side T1 port.

Note: By default, the SAL feature opens the tip side for 750 m/s in loop start operation. This is configurable in 10 m/s increments.

- In order to detect distant end disconnect for calls originating on the line-side T1 card, the “battery reversal” feature within the SAL software must be enabled. Enabling the “battery reversal” feature will not provide battery reversal indication when a call is answered; it will only provide battery reversal indication when a call is disconnected.
- In order to detect distant end disconnect for calls terminating on the line-side T1 card, the “hook flash” feature within the SAL software must be enabled.
- In order to detect distant end disconnect for calls originating and terminating on the line-side T1 card, both the “battery reversal” and “hook flash” features within the SAL software must be enabled.

Call disconnect from line-side T1 terminal equipment Alternatively, while a call is in process, the terminal equipment may disconnect by going on-hook, causing the line-side T1's receive A bit to change to 0. The line-side T1 card responds to this message by simulating the removal of ground from the tip by changing its transmit A bit to 1. The call is now terminated and the interface is once again in the idle condition.

[Table 5](#) outlines the line-side T1's A and B bit settings in each state of call processing.

Ground Start Restrictions

If you are using the line-side T1 card in ground start mode, certain restrictions should be considered. Because the Meridian 1 system treats the line-side T1 card as a standard loop start analog line card, the ground start operation of the line-side T1 card has operational limitations compared to typical ground start interface equipment relating to *start of dialing*, *distant end disconnect* and *glare potential*.

Distant end disconnect restrictions If the supervised analog line (SAL) feature is not available in your Meridian 1 software, the line-side T1 card is not capable of indicating to the CPE equipment when a call has been terminated by the distant end. In this case, the line-side T1 card will continue to provide a grounded tip indication (A=0) to the CPE equipment until it detects an open loop indication (A=0) from the CPE, at which time it will provide an open tip indication (A=1). Therefore, without SAL software, the line-side T1 card is not capable of initiating the termination of a call to the CPE equipment.

Since the X11 software releases 21 and later support the SAL feature, with these software releases this restriction does not exist. With the SAL software configured for each line-side T1 line, the line-side T1 card will provide an open tip indication to the CPE equipment when it receives an indication of supervised analog line from the Meridian 1 system, thus providing normal ground start protocol call termination.

Table 5
Ground Start Call Processing A/B Bit Settings

State	Transmit		Receive	
	A	B	A	B
Idle	1	1	0	1
Incoming Calls (to terminal equipment):				
— Idle	1	1	0	1
— Ringing is applied from line-side T1 card by simulating ground on tip lead and ringing on ring lead.	0	0/1	0	1
— Terminal equipment goes off-hook by simulating ground on tip lead and ringing on ring lead.	0	0/1	1	1
Outgoing Calls (from terminal equipment):				
— Idle	1	1	0	1
— Terminal equipment goes off-hook.	1	1	0	0
— The line-side T1 simulates grounding its tip lead	0	1	0	0
— Terminal equipment opens ring ground and closes loop	0	1	1	1
Call Disconnect from far end:				
— Steady state (call in progress)	0	1	1	1
— The line-side T1 ungrounds tip	1	1	1	1
— Terminal equipment opens loop current	1	1	0	1
Call disconnect from terminal equipment:				
— Steady state (call in progress)	0	1	1	1
— Terminal equipment goes open loop current	0	1	0	1
— Line-side T1 card opens tip ground	1	1	0	1

Glare restrictions In telephone lines or trunks, glare occurs when a call origination attempt results in the answering of a terminating call that is being presented by the far end simultaneously with the call origination attempt by the near end.

The line-side T1 detects presentation of a terminating call (outgoing to line-side T1 terminal equipment) by detecting ringing voltage. If application of the ringing voltage is delayed due to traffic volume and ringing generator capacity overload, the line-side T1 ground start operation cannot connect the tip side to ground to indicate the line has been seized by the Meridian 1.

In ground start mode, glare conditions need to be considered if both incoming and outgoing calls to the CPE equipment are going to be encountered. In the event that both the Meridian 1 and the CPE equipment simultaneously attempt to use a line-side T1 line, the Meridian 1 will complete the call termination rather than backing down and allowing the CPE equipment to complete the call origination, as in normal ground start operation. If both incoming and outgoing calls are to be handled through the line-side T1 interface, separate channels should be configured in the Meridian 1 system and the CPE equipment for each call direction, to eliminate the possibility of glare conditions on call origination.

Voice frequency audio level

The digital pad for line-side T1 card audio level is fixed for all types of call connection (0 dB insertion loss in both directions), and differs from the Meridian 1 analog line. Audio level adjustments, if required, must be made in the line-side T1 terminal equipment.

Off-premise line protection

Off-premise applications are installations where the telephone lines are extended outside the building where the PBX system is housed, but the lines are not connected to public access facilities. This application is commonly referred to as a “campus installation.”

In off-premise applications, special protection devices and grounding are required to protect PBX and telephone components from any abnormal conditions that might occur. Abnormal conditions include, but are not limited to, lightning strikes and power line crosses.

Two line cards, the NT1R20 Off-Premise Station Line Card and the QPC192 Off-Premise Extension Line Card, have built-in protection against lightning strikes and power line crosses. These should be the preferred cards for an off-premise application. Some of the other cards can be used when external line protectors are installed.

When using the line-side T1 card for an off-premise or network application, external line protectors must be installed. Install an isolated type channel service unit (CSU) as part of your terminal equipment to provide the necessary isolation and outside line protection. The CSU should be an FCC part 68 or CSA certified unit.

Line protectors

Line protectors are voltage-absorbing devices that are installed at the cross-connect terminals at both the main building and the remote building. The use of line protectors will ensure that system and telephone components are not damaged from accidental voltages that are within the limit of the capacity of the protection device. Absolute protection from lightning strikes and other stray voltages cannot be guaranteed, but proven cases have shown that the use of line protection devices significantly reduces the possibility of damage.

Northern Telecom has tested line protection devices from three manufacturers (see [Table 6](#)). Each manufacturer offers devices for protection of digital as well as analog telephone lines.

These devices are compatible with 66 type M1-50 split blocks or equivalent. Consult the device manufacturer if more specific compatibility information is required.

Line protection grounding

In conjunction with line protectors, proper system (PBX) grounding is essential to minimize equipment damage. Northern Telecom recommends that you follow the grounding connection requirements as described in *Meridian 1 system installation procedures* (553-3001-210). This requirement includes connecting the ground for the protection devices to the approved building earth ground reference. Any variances to these grounding requirements could limit the functionality of the protection device.

Table 6
Line protection device ordering information

Device order code		Manufacturer
Analog Line	Digital Line	
UP2S-235	UP2S-75	ITW Linx Communications 201 Scott Street Elk Grove Village, IL 60007 (708) 952-8844 or (800) 336-5469
6AP	6DP	Oneac Corporation 27944 North Bradley Road Libertyville, IL 60048-9700 (800) 553-7166 or (800) 327-8801 x555
ESP-200	ESP-050	EDCO Inc. of Florida 1805 N.E. 19th Avenue P.O. Box 1778 Ocala, FL 34478 (904) 732-3029 or (800) 648-4076

Line and telephone components

Because testing of the line protectors was limited to the line cards and telephones shown below, only these components should be used for off-premise installations.

Telephones

- Meridian Modular Telephones (digital)
- Meridian Digital Telephones
- Standard 500/2500 type analog telephones

Line Cards

- NT1R20 Off-Premise Station Line Card (Note 1)
- NT8D02 Digital Line Card (Note 2)
- NT8D03 Analog Line Card
- NT8D09 Analog Line Card with Message Waiting
- QPC192 Off-Premise Extension Line Card (Note 1)
- QPC578 Integrated Services Digital Line Card (Note 2)
- QPC594 16-port Line Card
- QPC789 16-port Line Card with Message Waiting

Note 1: The NT1R20 Off-Premise Station Line Card and the QPC192 Off-Premise Extension Line Card both have protection against lightning strikes and voltage surges built onto the card. These circuits protect the card and the PBX, but do not protect the instrument on the other end of the line. Line protection devices should still be installed at the cross-connect terminals at the remote building.

Note 2: When using line protection devices, the NT8D02 Digital Line Card and QPC578 Integrated Services Digital Line Card may experience digital line loop length reductions. The amount of loop length reduction depends on the device selected. As a general recommendation, 200 feet of line length reduction should be assumed for all digital lines equipped with protection devices. The loop length for analog lines equipped with protection devices is unaffected.

